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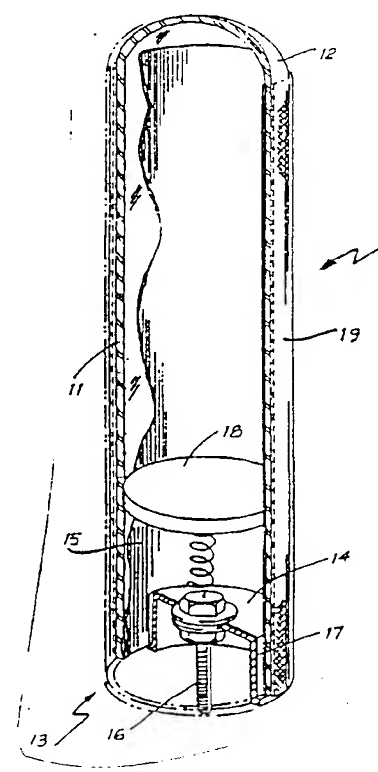
(54) Title: OZONE GENERATING APPARATUS

(57) Abstract

The present invention provides ozone generating apparatus for use in air conditioning systems for sterilizing the recirculated air. The apparatus can also be used in food preservation and other areas where bacteria and other micro-organisms need to be controlled. The apparatus comprises a lamp (10, 20, 40, 50, 60) consisting of a tube (11, 21, 41, 51, 61) which has an internal conductor (15) surrounded by a layer of dielectric material. Surrounding the dielectric material is a layer of metal mesh material or a printed grid of similar conductive pattern. The internal conductor is applied with a high voltage power supply, and the high voltage breaks through the dielectric material in corona discharge to the outer metal mesh. Oxygen which comes into contact with the corona discharge (electric field) is ionised forming ozone (03) which is used to disinfect infected areas.



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OZONE GENERATING APPARATUS

The present invention relates to air conditioning systems, and in particular, to ozone generators for the disinfection of air in air conditioning systems.

BACKGROUND ART

In air conditioning systems within buildings. any germs introduced into the building remain substantially trapped within the confines of the building. Bacteria and other micro-organisms are found on the internal walls of air conditioning ducting, vents and filters. Although air conditioning filters may be cleaned regularly, the internal walls of the air ducts are never cleaned. Under the right conditions an outbreak of disease may occur from the spread of the infective agents throughout the air conditioned building.

It has been found that ozone in air destroys micro-organisms by the process of oxidation. Ozone is thought to be particularly effective in the disinfection of ducts, vents and filters of air conditioning systems if ozone generators are installed in the ducting.

It is believed that ozone also helps to clear the air of microscopic airborne dust and smoke particles by the process of oxidation. Ozone is strongly magnetic and therefore magnetically attracts airborne dust and smoke particles. As they collide, bacteria, dust, smoke and fumes

and gases are quickly oxidised. In the process, the ozone molecules are neutralised or "spent" and divide into an oxygen molecule and an oxygen atom. The process, therefore, decontaminates the air and leaves no other residue or by-product than common oxygen.

Another use of ozone generators is in food preservation where the ozone cleans the air and kills bacteria and other micro-organisms which thereby causes perishable foods to last longer. The ozone generators can also be used for prevention of mould and bacteria growth in food processing and storage areas.

It is believed that the ozone slows the ripening of fruit and vegetables by destroying the ethylene gas given off my many fruits during the ripening process. The ozone destroys this harmful gas which acts as a catalyst to the ripening process and therefore prevents the risk of premature ripening of the fruit and vegetables.

Ozone generators also find a good use in other applications such as for example in hospitals, nursing homes and also in surgeries of doctors, dentists and veterinarians as well as in morgues and funeral parlors. They may also be used in the pharmaceutical industry for the processing and packing of drugs and medicines under more hygienic conditions. In the chemical industry ozone generators may be used to neutralise strong chemical fumes and odours. They may also be used to deodorise and clear the air in tanneries, paper mills, sewerage works and other industries where strong smells and odours are a problem.

Ozone generators also find a use in hotels, clubs, restaurants, canteens and kitchens to deodorise kitchen and beer odours and to clear the air of cigarette smoke. In cinemas and theatres they may be used to improve the comfort and attention span of patrons. Disruptive coughing and sneezing is reduced. Ozone generators may be used in shopping centres, supermarkets and shops. Food spoilage in supermarkets is reduced. They may also be used in animal breeding houses to keep pigs, poultry, horses, cattle etc. in more hygienic and healthier conditions.

OBJECT OF THE INVENTION

It is an object of the present invention to provide an improved ozone generator.

DISCLOSURE OF THE INVENTION

According to one aspect of the present invention there is disclosed ozone generating apparatus comprising a housing having a layer of dielectric material at least partially covered on either side by an inner and an outer layer of electrically conducting material, said layers being connectable to a power supply to apply a high voltage between said layers which causes a corona discharge through the dielectric layer thus converting oxygen to ozone when oxygen in the air comes into contact with corona discharge and wherein said inner layer is either painted onto said dielectric material or is metal deposited directly onto said dielectric layer.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the present invention will now be described with reference to the drawings in which:

Fig. 1 is a front perspective view of a ozone lamp according to the preferred embodiment of the present invention;

Fig. 2 is a cut away perspective view of the lamp of Fig. 1;

Fig. 3 is a cut away exploded perspective view of a lamp of a second embodiment:

Fig. 4 is a cut away perspective view of a lamp of a third embodiment;

Fig. 5 is a cut away perspective view of a lamp of a fourth embodiment;

Fig. 6 is a cut away perspective view of a lamp of a fifth embodiment;

Fig. 7 is a schematic diagram of a plurality of lamps of the preferred embodiment connected into a power supply circuit.

Fig. 8 is a plan view of an embodiment of a transformer to be used in the power supply; and

Fig. 9 is a plan view of a transformer of another embodiment: and

Fig. 10 shows views of a transformer of a preferred embodiment.

BEST MODES FOR CARRYING OUT THE INVENTION

A preferred embodiment of the present invention is illustrated in *Fig. 1 and 2*. A lamp 10 comprises a glass tube 11 having one end 12 domed and the other end 13 open. A plug 14 made of plastics material is fitted into the open end 13. The glass tube 11 has a painted inside surface 15. The surface 15 is painted with a conductive paint and/or

ink made from graphite, carbon black, silver, gold, nickel, chrome, stainless steel, iron, zinc, tin, aluminium, copper, lead, mercury or any other suitable conductive material. A 10 mm margin at the bottom of the tube is left unpainted to prevent arcing. Alternatively, the inside surface 15 can be metal deposited directly onto the glass tube 11. The tube 11 can alternatively be made of ceramic material or any other suitable dielectric.

It has been found that if the internal conductive surface 15 is a graphite or carbon black surface coating, no corrosive action can take place and therefore it is not necessary to evacuate the air and fill the lamps 10 with an inert gas. Therefore, the use of graphite or carbon black is a less expensive and long wearing coating for the inside lamp surface. The output of ozone lamps using an internal graphite or carbon black conductive coating also remains constant almost indefinitely and does not diminish with time due to the absence of corrosion on the critical area of the internal lamp coating. The working life of the lamps is therefore extended almost indefinite with virtually no loss of performance due to the use of a graphite an/or carbon black internal lamp coating. The durability of the graphite and/or carbon black coating is only limited by the durability of the dielectric tube to which the coating is applied.

Through the centre of the plug 14 is fitted a mounting bolt 16. The mounting bolt 16 is connectable to a power supply 70 illustrated in Fig. 7. The plug 14 has an external surface 17 which contacts the

inner surface 15 of the glass tube 11. The external surface 17 of the plug 14 is coated or metallised in the same manner as the inside surface 15 of the glass tube 11. The surface 15 and 17 therefore make electrical contact. The plug 14 is glued into the base of the tube 11 and/or a circular, spring loaded clip 18 can also be inserted into the interior of the glass tube 11. The clip 18 is electrically connected to the mounting bolt 16 and acts as an extra contact surface to the inside surface 15 of the tube 11.

A tight fitting, fine stainless steel mesh 19 is fitted over the outside surface of the tube 11. The mesh 19 acts as an earth conductor as it is connectable to earth (not illustrated). The size and dimensions of the stainless steel mesh 19 play an important part in the production of ozone. For the purpose of this invention, the desirable dimensions of the mesh openings are up to 5 mm diameter, the optimum size being about a 2-3 mm diameter opening for lamps powered by a transformer operating at 50-60 cycles and a mesh opening of about 1-2 mm for lamps powered by a transformer operating at higher frequencies. The mesh is preferably made of thin stainless steel wire or other non corrosive conductor. It has been found that with mesh of these respective opening sizes, the individual corona flares produced by the corona discharge are of optimum size. Increasing the respective size of the openings does not increase the size of the individual corona flares and, in fact, if the mesh size is increased beyond the respective optimum size, a lesser amount of ozone may be produced because an inactive area opens up in the centre of the mesh opening.

This inactive area can be seen in the dark as a dark spot on the surface of the lamp. Alternatively, if the mesh size is reduced below the respective optimum dimensions then the size of the individual corona flares is correspondingly reduced in relation to the surface generating area of the opening. The smaller the mesh opening, the smaller the surface generating area and accordingly the smaller the individual corona flares. Furthermore, the greater and stronger the individual corona flares, the greater the electrical charge imparted into the ozone and the longer the life-span of the individual ozone molecule. For ozone intended to be used in air conditioning ducting systems, the volume of ozone is not as important as the life-span of the ozone as mostly the ozone has to travel long distances in the ducts before emerging from the vents. It is not desirable for the ozone molecules to die enroute in the ducts before reaching their destination. One the object of this invention is for sufficient ozone molecules to emerge from the vents to continue ozone treatment of the whole airspace of the premises serviced by the air conditioning installation and not just the ducts or section of the ducts. The mounting bolt 16 contacts the external surface 17 of the plug 14 to make an electrical connection between the mounting bolt 16 and the inside surface 15. In operation, a high voltage is applied to the mounting bolt 16 thereby charging the inside surface 15 of the tube 11. The voltage discharges through the dielectric glass or ceramic tube 11 to the mesh 19 thus causing a corona discharge. As air passes through the corona discharge, the oxygen in the air is ionised thus forming ozone. The fine stainless steel mesh 19 can be replaced by a

conductive printed grid on the external surface of the glass tube 11. The conductive printed grid acts in the same way as the stainless steel mesh 19.

Another embodiment of the present invention is illustrated in *Fig. 3* and comprises a lamp 20 which consists of plastics tube 21 of square cross-section. Each of the sides 22 of the tube 21 has a circular hole 23 passing therethrough. A first glass panel 24 is glued onto each of the sides 22. Each of the glass panels 24 has a hole 25 corresponding to, and aligned with, the hole 23 in the plastics tube 21. The tube 21 has a lid 26 and a plug 27. The plug 27 has a mounting bolt 28 similar to the embodiment illustrated in Figs. 1 and 2. A path 29 is painted on the inside of the tube 21 using a conductive paint similar to those described above in relation to the first embodiment. Alternatively, a metal conductor takes place of the path 29 and connects the mounting bolt 28 to the holes 23 and 25. The path 29 passes through the holes 23 and 24 and onto an annular ring 30 situated on the first glass panel 24. A second glass panel 31 having one surface 32 metalised is glued onto the first glass panel 24. The metallised surface is glued onto the first glass panel 24. The metallised surface 32 contacts the conducting path 29. A border 33 is around the edges of the second glass panel 31 to prevent leakage flux. The metallised surface on the second glass panel can alternatively be painted in a similar manner to that described above in relation to the first embodiment of Fig. 1 and 2. Similarly, to the lamp 10, lamp 20 has a fine stainless steel mesh 33 which is slipped over the outside of the tube 21 covering the whole

length thereof. Once again, the mesh 33 acts as an earth conductor. The mesh 33 can be replaced with a printed conductive grid similar to the alternative described above.

A third embodiment of the present invention is illustrated in *Fig. 4* and comprises a lamp 40 which consists of tube 41 of low carbon steel or aluminium, having a coating 42 made of vitreous enamel or plastics material. The steel or aluminium tube 41 is a conductive material and the coating 42 of vitreous enamel or plastics is a dielectric material. Plastics sheeting can be wrapped around the steel or aluminium tube in place of the plastics coating. The preferred types of plastics wrap around sheeting are Cellulose Acetate and/or Acrylic. One end of the tube 41 is closed with a plastics dome 43 and the other end 44 is open. The open end 44 of the tube 41 has a plastics plug 45 fitted therein. The outside surface 46 of the plastics plug 45 is painted with a conductive paint. A mounting bolt 47 passes through the plastics plug 45 similar to that of the embodiment illustrated in Fig. 1 and 2. A spring loaded clip 48 is located within the tube 41 in a similar manner to that of the lamp 10. Once again, a fine stainless steel mesh 49 is slipped over the outside of the tube 41 covering the coating 42 along the whole length of the tube 41. A voltage applied to the mounting bolt 47 and the steel or aluminium tube 41 discharges in a corona through the vitreous enamel or plastics coating/sheeting 42. The mesh 50 can be replaced with a printed conductive grid similar to the alternative described above.

Another embodiment of the present invention is illustrated in *Fig. 5* and comprises a lamp 50 which consists of a glass tube 51. One end 52 of the tube is domed and the other end 53 is open and is fitted with a silicone rubber or plastics plug 54. The silicone or plastics plug 54 is an important feature of the lamp 50 because in other conventional gas filled lamps, the glass envelope is heat sealed at both ends and if there is any gas pressure loss or other defect, the lamp has to be discarded. The silicone or plastics plug 54 can easily be pierced with a thin hypodermic needle and the gas in the lamp can be evacuated and/or refilled and/or re-pressurised any number of times and thus the service life of the lamp may be extended almost indefinetely at minimal cost. With the silicone or plastics plug, the lamp becomes a re-usable lamp and the service life of the lamp is limited only by the durability of the dielectric tube. A mounting bolt 55 passes through the centre of the silicone or plastics plug 54 and an ignition electrode 56 is fitted to the bolt 55. The plug 54 is sealed in the glass tube 51 with the electrode 56 protruding inside the tube. A vacuum is created inside the sealed tube 51 and then one or two drops of mercury are injected into the tube 51, the vacuum therefore vaporizes the mercury into a mercury vapour. A tight fitting fine stainless steel mesh 51 is slipped over the outside of the tube 51 forming an earth conductor. A fine printed conductive grid can be substituted for the mesh, as described above. In use, a high voltage is conducted via the mounting bolt 55 to the electrode 56 which ionises the mercury vapour. The ionised vapour inside the tube 51 provides that the inside of the tube 51 has a voltage potential

thereby a corona discharges through the dielectric glass tube 51 to the earth conductor. Once again, the tube can be made of ceramic material. Alternatively, the tube 51 can be filled with an inert gas such as Neon, Argon, Freon or Sodium Vapour etc. which is ionised by the voltage potential. The ionised gas conducts the electrical current, producing a voltage potential inside the tube 51 similar to that of the mercury vapour.

Another embodiment of the present invention is illustrated in *Fig. 6* and comprises a lamp 60 which consists of a glass or ceramic tube 61. Both ends of the tube 61 are open and has plastics plug 62 and 63 inserted therein. In the plug 63, a mounting bolt 69 is fitted through the centre thereof. A path 64 of conductive paint is painted on the inside of the tube 61 to two holes 65 located on the sides of the tube 61. Alternatively, metal strips or other conductors can be used. The path 64 of conductive paint is electrically connected to the interior surface of two curved glass panels 66 which are fitted around the tube 61. The interior surface has been metallised or painted similar to the embodiment illustrated in Fig. 3. A conductive grid is printed onto the outer surface of the panels 66. An unprinted margin of about 5 mm is left around the edge of each circuit panel to prevent leakage flux. The grid 67 is connectable to the earth conductor. The lamp 60 is operated in a similar manner to those of the other embodiments of the invention.

As illustrated in *Fig. 7*, the lamps 10 of the first embodiment are screw mounted to a power supply unit 70. The power supply unit 70 includes a high voltage AC transformer or high voltage pulsed D.C. power supply unit 71, connected to a 120 and/or 220 and/or 240 volt AC mains power supply, an on/off switch 72, a fuse holder and/or circuit breaker 73 and a pilot light 74. The active A, the neutral N and earth E are indicated in Fig. 7. The high voltage output 75 of the transformer 71 is connected to the mounting bolts 16 of the lamps 10. In operation, the lamps of the various embodiments are attached to the power supply unit 70 and when the unit 70 is switched on, a corona discharge is produced on the outside surface of the lamps 10 thus ionising oxygen into ozone.

It has been found that with conventional ozone lamps. nitric oxide is usually produced as a contaminant in association with ozone at a threshold of 3000 volts. In the lamps of the present invention this threshold has been overcome due to the combination of the design of the lamps and the design of the transformer and therefore voltage restrictions no longer apply. The voltage applied and the intensity of the corona discharge achieved and the amount of ozone produced by the lamps of the various embodiments is only limited by the dielectric strength (breakdown voltage) of the dielectric material of the lamps. Due to the higher and unrestricted voltages being able to be applied, a greater amount of "clean" uncontaminated ozone is able to be produced by the lamps of the present invention.

Except for the mercury vapour and gas filled lamps of the fourth embodiment and illustrated in Fig. 5, no conventional ignition electrodes and no starters are required.

Most types of conventional transformers have a common purpose in that they are designed to be used with a resistive load. These transformers perform very well with a resistive load and if the sinewave is viewed on an oscilloscope, the sinewave will be seen to be clean and undistorted. However, if the same transformer is subjected to a purely capacitive load, the sinewave will be seen to change and reveal spikes and distortions. The lamps of the various embodiments have the same basic characteristics as a capacitor and therefore in operation the lamps behave same as a capacitor.

This anomaly is particularly evident in conventional high voltage leakage reactance transformers with a magnetic shunt which is the most common type of high voltage transformer used. The reason for the popularity of shunted leakage reactance transformers is that the magnetic shunt and built-in current limiting prevents the transformer from burning out in the event of a short circuit. All other types of transformer don't have this built-in short circuit protection. In high voltage applications, out of necessity, only transformers with a magnetic shunt and built-in current limiting are commonly used because the higher the voltage, the greater the risk of arcing and/or short circuiting becomes. Furthermore, if a capacitive load is connected to a transformer, the voltage rises above the rated voltage and thus

further increases the risk of arcing. With a resistive load, the voltage does not increase.

It is obvious that conventional transformers and in particular shunted leakage reactance transformers have an inherent design malfunction under a capacitive load.

It has been found that ozone is produced by the free, unhindered and uninterrupted peak to peak oscillation of the current. The greater the peak to peak oscillations, the higher the voltage and current and the greater the production of ozone. If there are any interruptions, distortions and/or interference in the free peak to peak oscillation of the waveform then the ozone production is accordingly impaired and as a substitute nitric oxide contamination is increasingly produced.

The problem with conventional shunted leakage reactance transformers is in the design of the magnetic shunt and current limiting. If a capacitive load is connected to the high voltage transformer, leakage flux fringes between the magnetic shunt and the core and/or between the coils and the core. This leakage flux produces spikes and distortions which hinder the free peak to peak oscillation of the waveform. The greater the interference, the greater the impairment of ozone production. The problem is solved by inserting insulation between the magnetic shunt and the core and also by inserting extra insulation material between the coils and the core because leakage flux can also occur there. Alternatively, should the extra insulation

be ineffective then the gap between the coils and the core will have to be increased. Any interference in the running of the high voltage transformer is thus stopped, irrespective whether it is a resistive or a capacitive load.

Conventional high voltage transformers are not satisfactory for use with the present invention because:

(a) with a normal transformer (without a magnetic shunt) if arcing or a short circuit occurs, the transformer will burn out. As short circuit protection, a circuit breaker and/or fuse and/or current limiting device therefore has to be added to this type of transformer.

(b) a leakage reactance transformer with a magnetic shunt and current limiting, whilst providing short circuit protection, is also unsatisfactory because that type of transformer produces spikes and distortions to the voltage and current caused by leakage flux fringing between the magnetic shunt and the core and between the coils and the core. These spikes and distortions in the high voltage waveform put considerable extra stress on the dielectric material and are the cause of a reduced ozone output and also cause the production of nitric oxide contamination. Therefore, conventional leakage reactance transformers with a magnetic shunt have an inherent handicap in that they produce interference to the free peak to peak oscillation of the high voltage waveform and thus accordingly impair the production of ozone and at the same time cause nitric oxide contamination.

The high voltage transformers to be used with the present invention therefore are of a special design. The overriding requirement being that the transformers produce a pure and undistorted sinewave under operating conditions with a capacitive load. The sinewave produced must be either a pure sinusoidal waveform or a pure square waveform or a pure pulsating waveform in either A.C. or D.C. current.

Type 1 is a normal 50-60 cycles (low frequency) high voltage A.C. transformer without a magnetic shunt. As short circuit protection, a circuit breaker and/or fuse and/or current limiting device is added to the transformer.

Type 2 (Fig. 8-10) is a normal 50-60 cycles (low frequency) high voltage A.C. leakage reactance transformer with a magnetic shunt and built-in current limiting. The problem of fringing of leakage flux is solved by inserting insulation between the magnetic shunt and the core and also by inserting extra insulating material between the coils and the core to prevent any leakage flux from occurring there. Should the extra insulation prove ineffective then alternatively the gap between the coils and the stack will have to be increased. With this modification, the transformer does not produce any more interference in the form of spikes and distortions to the sinewave of the high voltage output. If viewed on an oscilloscope, the sinewave of the modified transformer under operating conditions with a capacitive load now looks pure and undistorted. With this special modification to the transformer, the extra stress on the dielectric has been removed and

the lamps are able to operate at extremely low temperature and higher voltage. The combination of the higher working voltage and amperage and the free and unhindered peak to peak oscillations of the waveform can result in up to several times the amount of ozone output over that able to be produced with the same transformer without these modifications.

Type 3 is a high frequency, high voltage power supply unit. It has been found that the higher the operating frequency of the transformer, the higher the working voltage the lamps are able to operate at and the higher the amperage and volume of ozone produced. The frequency could be anywhere from 50-60 cycles (hz) to several million cycles (hz). With a high frequency transformer, the working voltage can be anything from several hundred volts to several million volts. Given a high frequency, high voltage power source, the voltage applied and the discharge amperage achieved by the lamps of the various embodiments is only limited by the dielectric strength (breakdown voltage) of the dielectric material of the lamps and is dependent on the frequency to voltage relationship of the power source. The higher the voltage applied, the higher the frequency must be. It has been found that there is a relationship between a given voltage and frequency. It is apparent that as the frequency of the source voltage increases, capacitive reactance decreases and current increases ($X_c = \frac{1}{2\pi f C}$ and $I_c = \frac{E_A}{X_c}$). For example, at 50 cycles (Hz), the operating voltage of the lamps is about 5000 volts, however, the same lamps at an operating frequency of 5000 cycles (Hz), are able

to operate at a voltage of up to 15,000 volts. The ozone output of the lamps of the various embodiments with a high frequency, high voltage transformer can be up to many times higher than with a conventional transformer, provided the sinewave of the high frequency, high voltage transformer under operating conditions with a capacitive load is pure and undistorted.

In order to produce a pure and undistorted sinewave under operating conditions with the lamps of the various embodiments, the high frequency, high voltage power supply unit to be used with the present invention can incorporate a step-down transformer and/or a current rectifier, a frequency regulator/modulator and a voltage booster transformer.

The basic principle in the preferred configuration of a high frequency, high voltage power supply unit is (I) to convert the 50-60 cycles mains A.C. power supply to a D.C. current by using a step-down transformer and/or a current rectifier. At this point a fuse and/or circuit breaker and/or current limiting device can be added to the circuit. (II) The D.C. current can then be pulsed using a frequency regulator/modulator to produce any desired frequency. (III) The output voltage of the D.C. waveform is then boosted by a voltage booster transformer to any desired voltage.

Other types of transformer that can be used in the configuration of a high frequency, high voltage power supply unit can be either:

(a) a leakage reactance transformer with a magnetic shunt and current limiting similar to Type 2 described above.
(b) a transformer with or without a magnetic shunt, with or without an added circuit breaker and/or fuse and/or current limiting device. The transformer can be either a toroidal transformer, ferro resonant transformer, induction coil transformer with or without a spark gap, ignition coil transformer with or without a spark gap, tesla coil transformer with or without a spark gap or any other type of transformer provided the transformer produces a pure and undistorted sinewave under a capacitive load.

Illustrated in *Fig. 8* is one embodiment of a transformer 81 to be used with the ozone generator of the present invention. The transformer 81 comprises an iron core 82 with a primary winding 83 and secondary winding 84 wound on the middle leg of the core 82. Any exposed section of the core 82, between the primary coil 83 and secondary coil 84 is insulated on all four sides to prevent fringing of magnetic flux between the core 82 and the magnetic shunt/current limiting stack 87. Brackets 86 to hold the transformer together are located at the edges of the transformer core. Two magnetic shunts/current limiting stacks 87 are placed on opposed sides of the centre leg of the core 82. The magnetic shunt/current limiting stacks 87 prevent overloading and destruction of the transformer in the event of a short-circuit.

Another embodiment of the transformer 91 is illustrated in *Fig. 9*. The transformer 91 comprises a core 92 and magnetic shunt/current limiting

stack 97 with the primary winding 93 and secondary winding 94 being wound on the outside legs of the three legged core 92. Insulation 95 is located next to the windings 93 and 94 to prevent fringing of magnetic flux. Further insulation 96 is placed at both ends of the magnetic shunt/current limiting stack 97 to prevent fringing of leakage flux between the current limiting stack 97 and the core 92.

Yet another embodiment of a high tension transformer is shown in *Fig. 10*. This transformer comprises a two legged core (c-core) 100 with the primary coil 101 and the secondary coil 102 wound on the same leg. The primary coil is approximately 25 mm in width and the secondary coil is approximately 60 mm in width. A magnetic shunt/current limiting stack 103 connects between the two core legs as shown. The magnetic shunt/current limiting stack 103 is approximately 5 mm wide. A 5 mm wide air gap 104 separates the primary coil 101 from the bobbin 105 of the secondary coil 102. The secondary coil 102 is wound on the bobbin 105 so as to leave a 10 mm margin 106 clear of windings on both sides of the bobbin 105. The 10 mm margin 106 is necessary to prevent arcing and/or fringing of magnetic flux on the sides of the coil and is a preferred and essential feature of all transformers to be used with the present invention. The overall outside dimensions of the transformer are 130 mm by 60 mm by 80 mm with the primary and secondary coils extending proud of the 80 mm dimension by approximately a further 20 mm. The transformer provides an output of approximately 5000 VAC RMS 50 Hz at max. 10 mA on the secondary coil given a 240 VAC 50 Hz mains supply to the primary coil. The exposed

portion of the core 100 between the primary coil 101 and the secondary coil 102 is insulated on all four sides to prevent fringing of leakage flux mainly between the magnetic shunt 103 and the exposed section of core 100.

The transformers to be used with the present invention can be encapsulated with epoxy or similar substance for moisture protection and safety.

The foregoing describes only some embodiments of the present invention, and modifications obvious to those skilled in the art can be made thereto without departing from the scope of the present invention.

For example, the above mentioned transformer types can have the construction as described above and be adapted to be used with a D.C. power source to provide a pulsed D.C. output due to the control of the input. The pulsed D.C. output is another way of obtaining a peak to peak output voltage of the desired sinewave shape.

CLAIMS

OZONE GENERATING APPARATUS

1. Ozone generating apparatus comprising a housing having a layer of dielectric material at least partially covered on either side by an inner and an outer layer of electrically conducting material, said layers being connectable to a power supply to apply a high voltage between said layers which causes a corona discharge through the dielectric layer thus converting oxygen to ozone when oxygen in the air comes into contact with corona discharge and wherein said inner layer is either painted onto said dielectric material or is metal deposited directly onto said dielectric layer.

2. The apparatus of claim 1, wherein said inner layer comprises conductive paint made from either graphite or carbon black.

3. The apparatus of claim 1, wherein said inner layer comprises conductive paint made from one of silver, gold, nickel, chrome, stainless steel, iron, zinc, tin, aluminium, copper, lead,mercury.

4. Apparatus as claimed in claims 1-3, wherein the layer of dielectric material is a thin walled glass or ceramic tube having one open end, the tube having an inside surface coated with said inner layer of conducting material and having a grid-like pattern forming said outer layer of conductive material, an insulated mounting means being inserted into said open end of said tube, wherein said mounting means having an electrical contact electrically connected to said inner layer of conducting material and to said high voltage power supply.

5. Apparatus as claimed in claim 4, wherein said electrode further comprises an auxiliary connection from said mounting means to said inner layer of conducting material.

6. Apparatus as claimed in claims 1-3, wherein said inner and outer layer of conducting material and said dielectric layer are located on a tube of insulating material, said inner layer is coated onto inside said dielectric layer and said outer layer comprises a grid-like pattern on

outside of said dielectric layer, said layers at least partially covering said tube, an insulating mounting means located within one end of said tube and having an electrical contact connected to said inner layer by a conductive path, whereby said electrode is connectable to said high voltage power supply.

7. Apparatus as claimed in claim 6, wherein said tube has a square cross section and said inner layer and said dielectric layers are located in separate segments, each being on one of the sides of said tube, said outer layer at least partially covering said dielectric layer.

8. Apparatus as claimed in claim 6, wherein said tube has a circular cross section and said outer layer is in two separate segments surrounding said dielectric layer.

9. Apparatus as claimed in claim 1, wherein said inner layer comprises a metal tube and said dielectric layer is a coating of vitreous enamel or plastics and/or wrap around plastics sheeting on the outside of said tube, said outer layer comprises a grid-like pattern or mesh covering outside of said enamel or plastics coating/sheeting, an insulated mounting means located within one end of said tube and having an electrode connected to said tube and to said high voltage power supply.

10. Apparatus as claimed in claim 1, wherein said dielectric layer comprises a glass or ceramic tube having one open end and said outer layer comprises a grid-like pattern on outside of said tube, and said inner layer comprises a mercury vapour, sodium vapour, neon gas, argon gas or freon gas or any other conductive inert gas which is connected to an electrode which is part of a mounting means which fits into the open end of said tube, said electrode being connected to said high voltage power supply.

11. Apparatus of any one of claims 2-9, wherein the internal dimensions of each grid of said grid mesh is in the range of 2-3 mm diameter when said high voltage power supply operates at a frequency of 50-60 Hz and in the size range of 1-2 mm diameter when the high voltage

power supply operates at higher frequencies.

12. The apparatus of any preceding claim including a high voltage transformer, the high voltage output of which is connected to said ozone generating apparatus, said transformer producing either a pure sinusoidal sinewave or a pure square waveform or a pure pulsating waveform under operating conditions.

13. The apparatus of claim 12, wherein said transformer is a leakage reactance transformer with a magnetic shunt thereby incorporating inherent current limiting and providing a pure sinusoidal waveform under operating conditions.

14. The apparatus of claim 13, wherein said transformer incorporates insulation between the magnetic shunt and the core and also incorporates extra insulation material between the coils of the transformer and the core to prevent fringing of leakage flux.

15. The apparatus of either claim 13 or 14, wherein in addition or alternatively an enlarged air gap is left between the coils of the transformer and the core to prevent fringing of leakage flux.

16. Apparatus of any one of claims 12-15, wherein the secondary coil of the transformer has a margin of up to 10 mm on either or both sides clear of any windings to prevent fringing of leakage flux on the sides of the coil.

17. Apparatus of any one of claims 12-16, wherein the high voltage power supply operates at frequencies of either 50-60 Hz or higher frequencies and providing a pure sinusoidal waveform or pure square waveform or pure pulsating waveform under operating conditions.

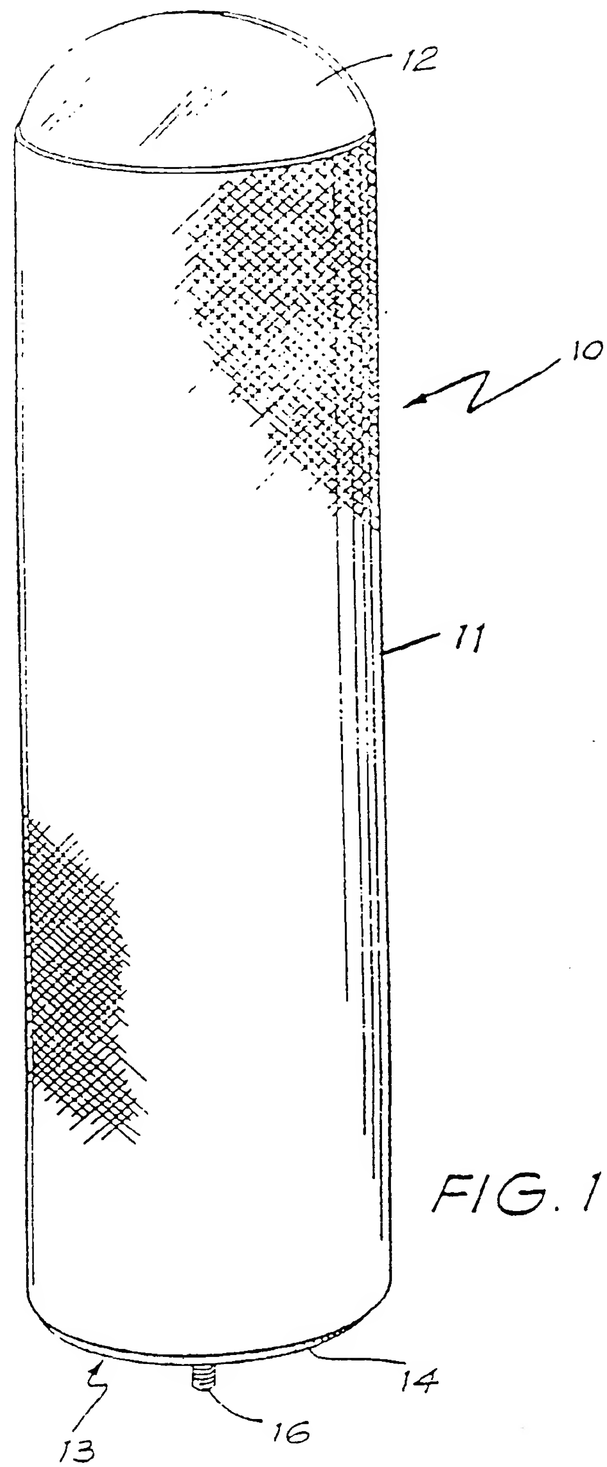

FIG. 1

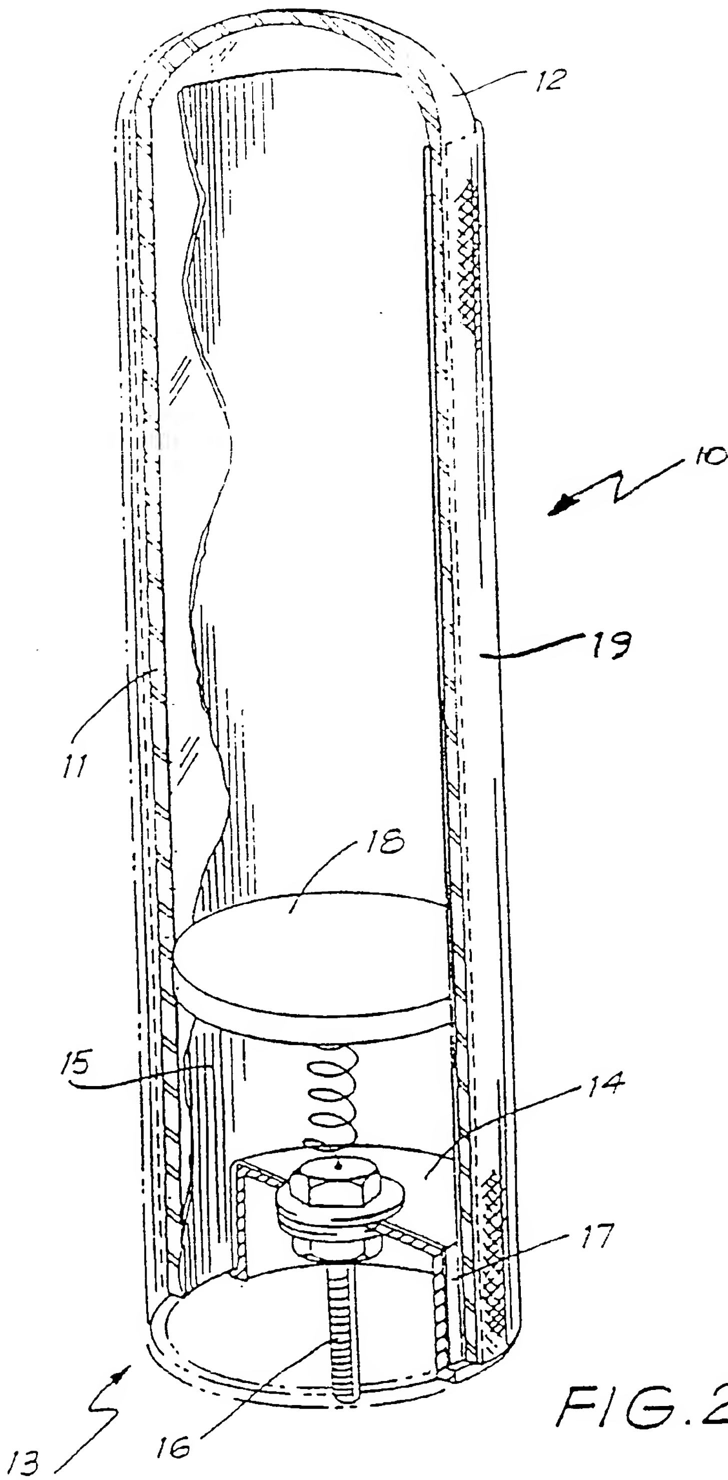

FIG.2

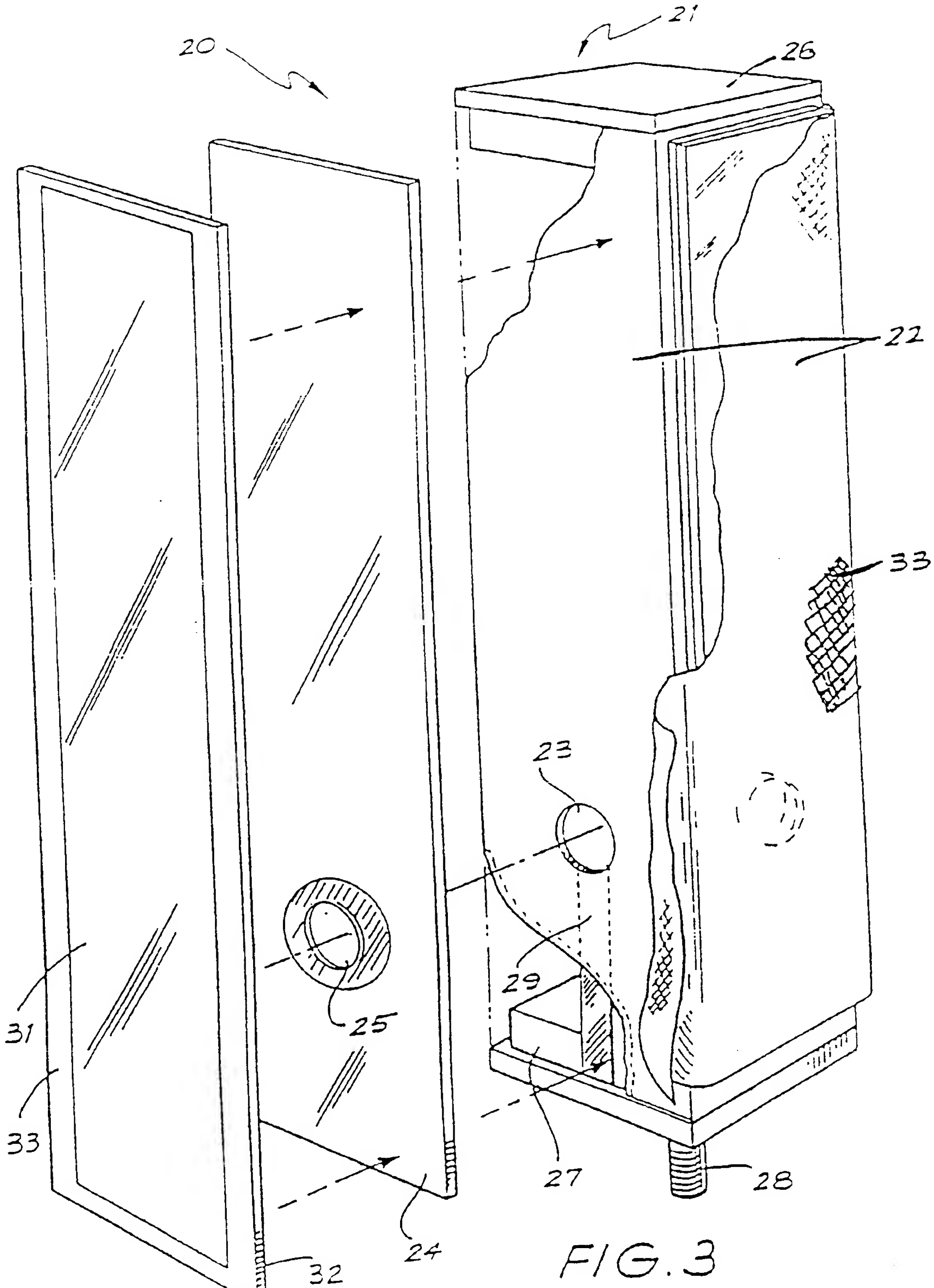

FIG. 3

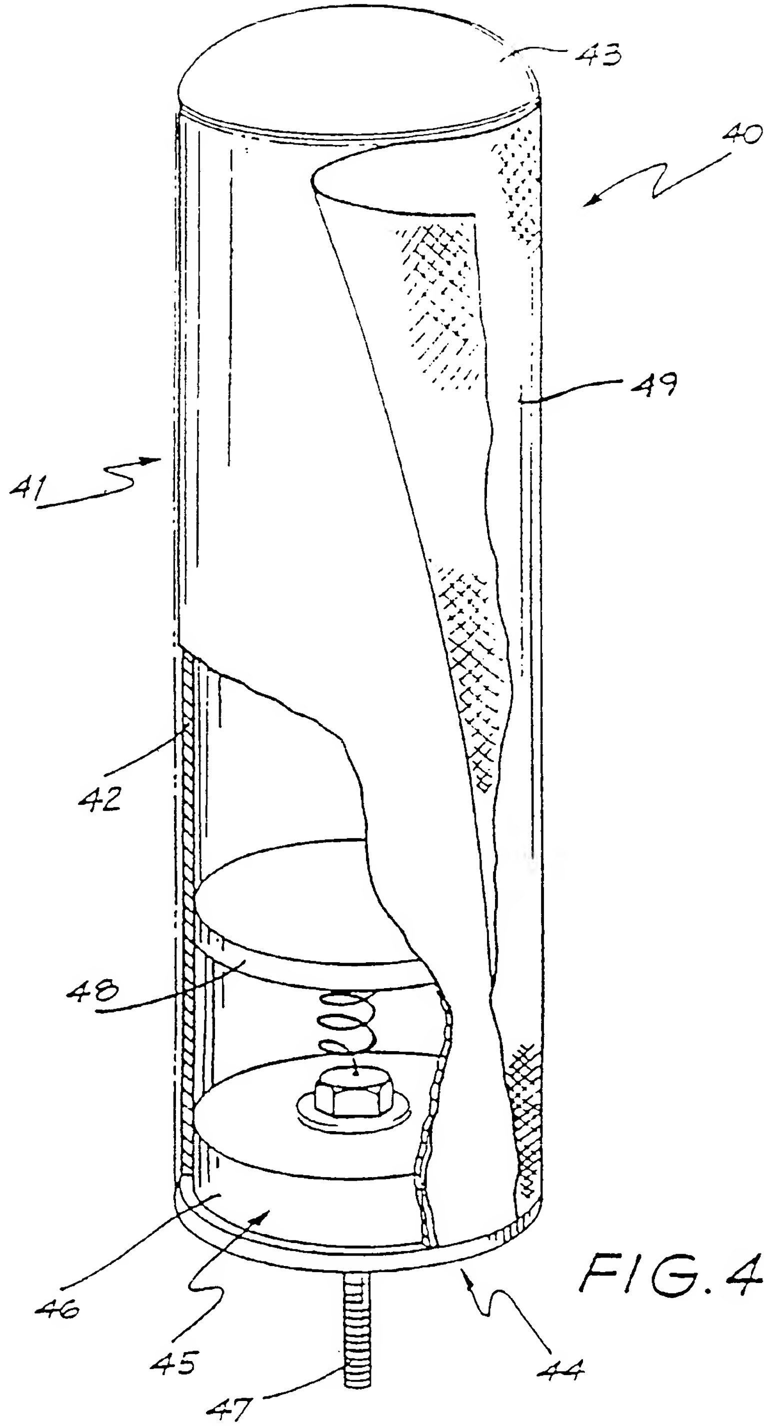

FIG.4

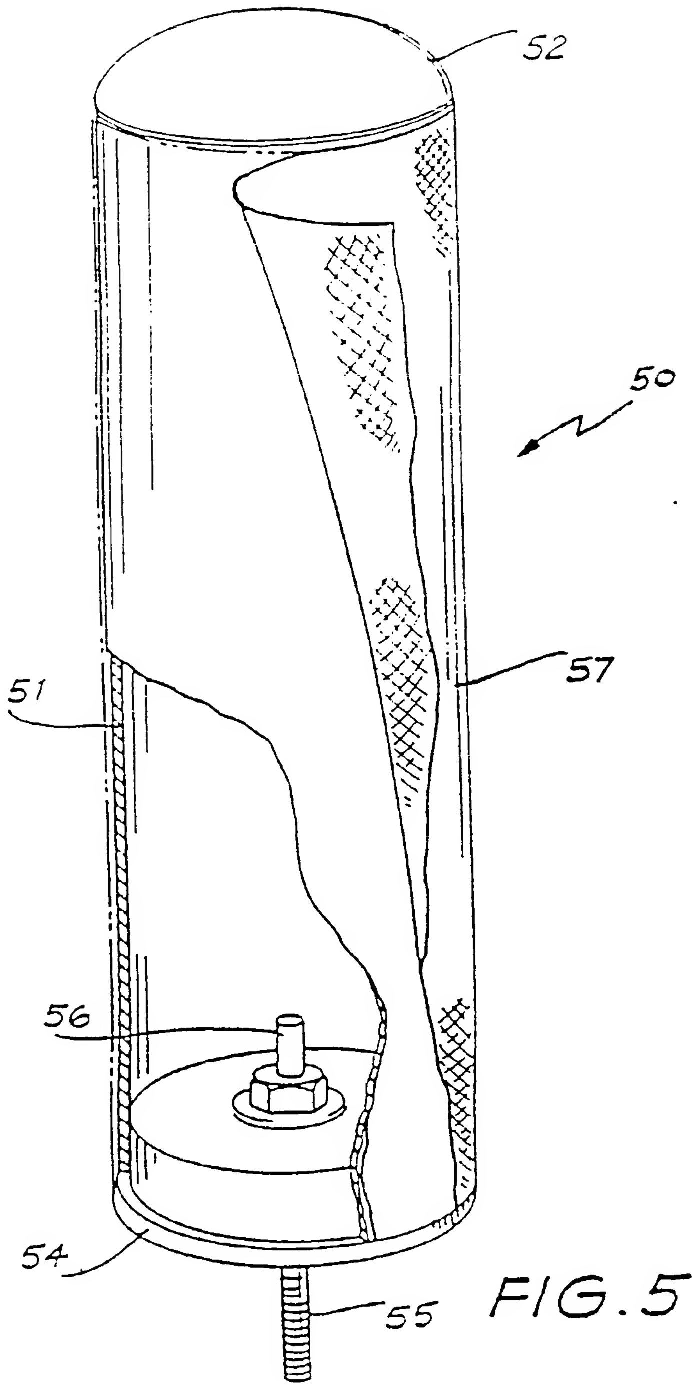

FIG.5

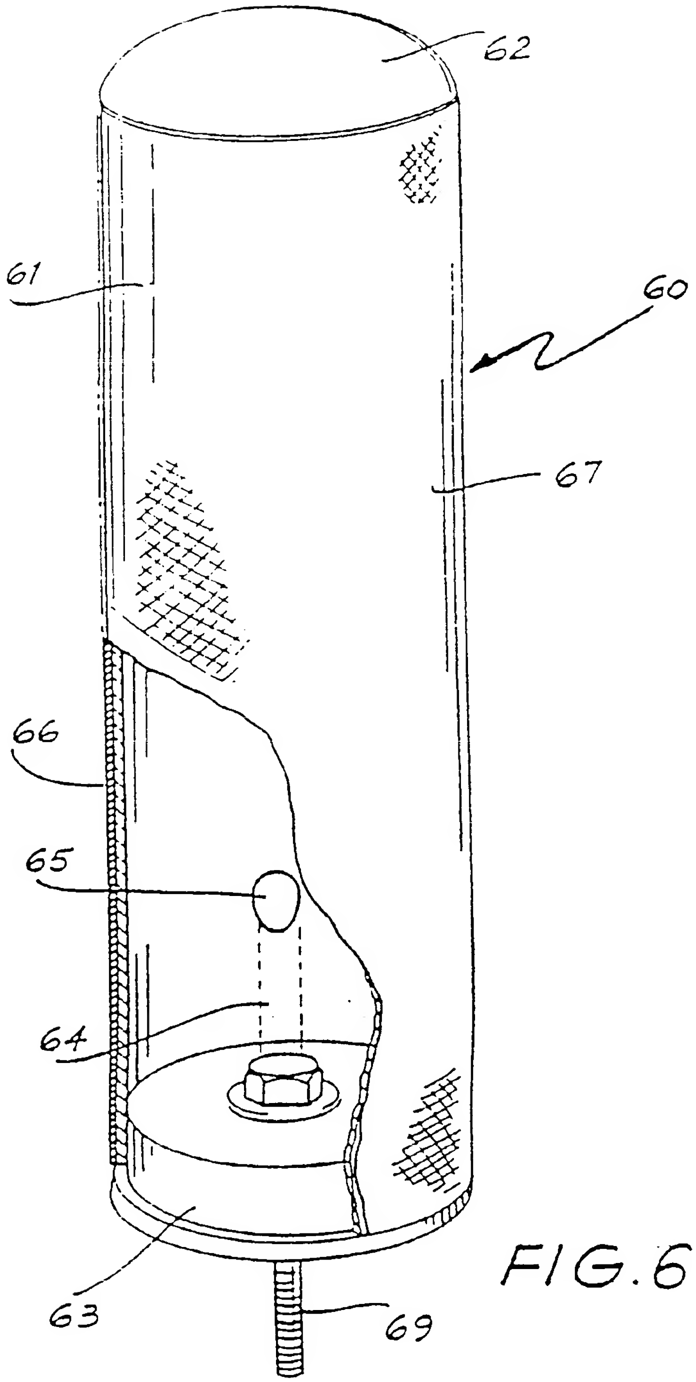

FIG.6

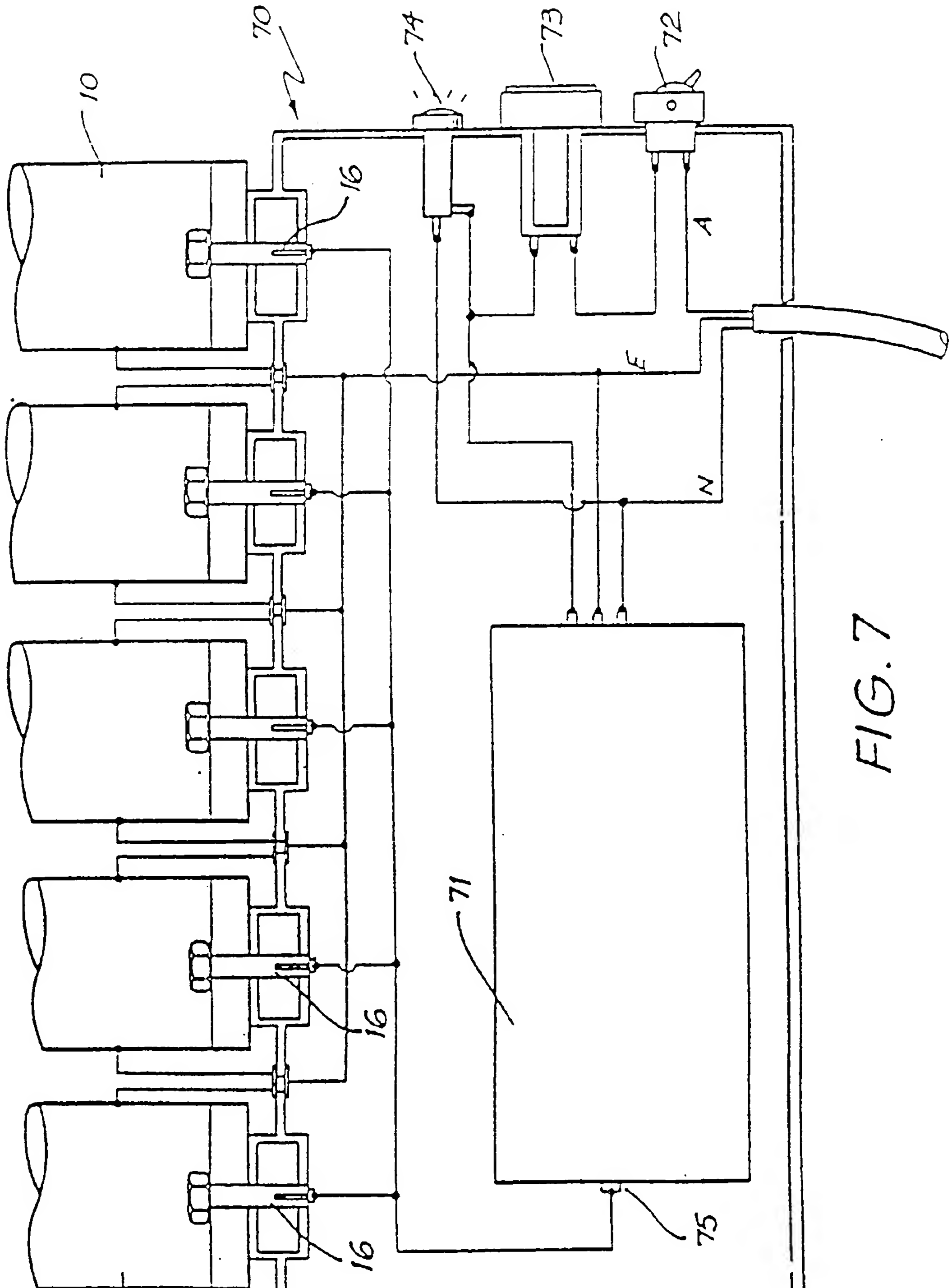

FIG. 7

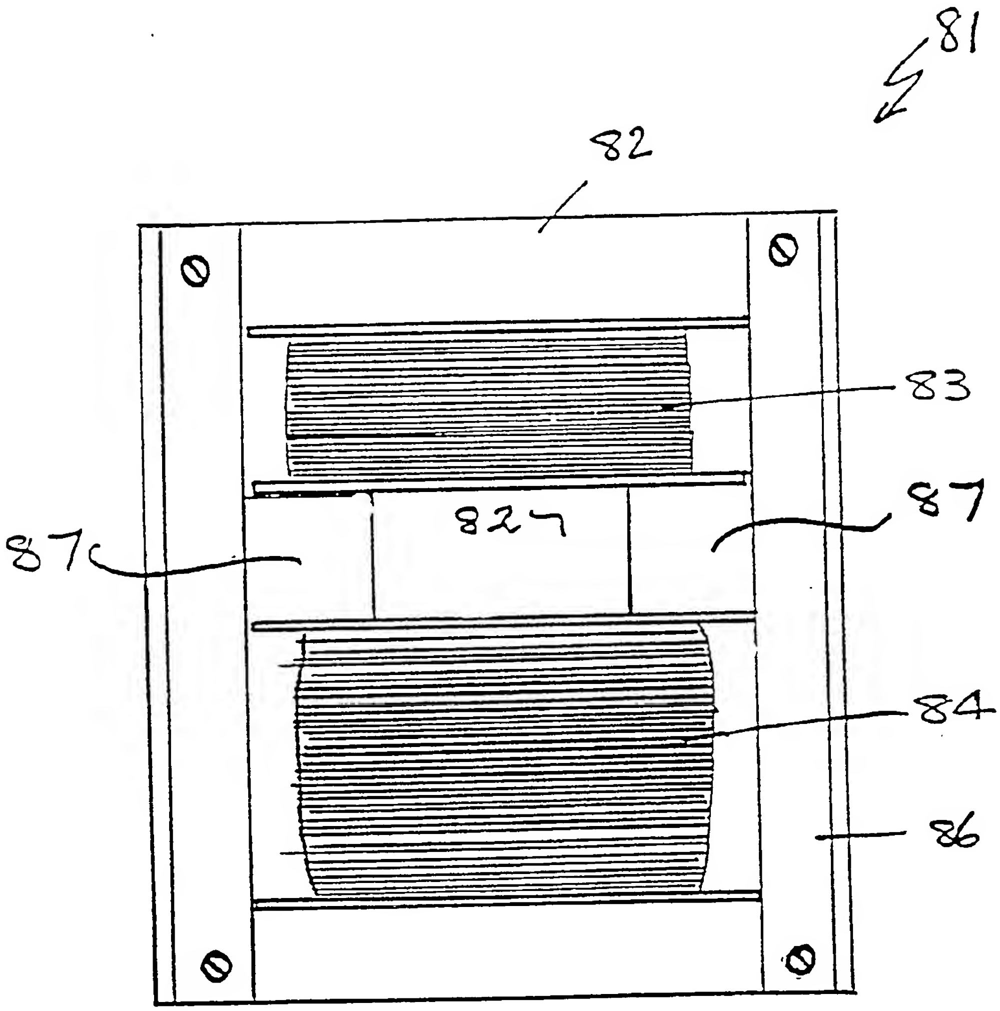

Fig 8

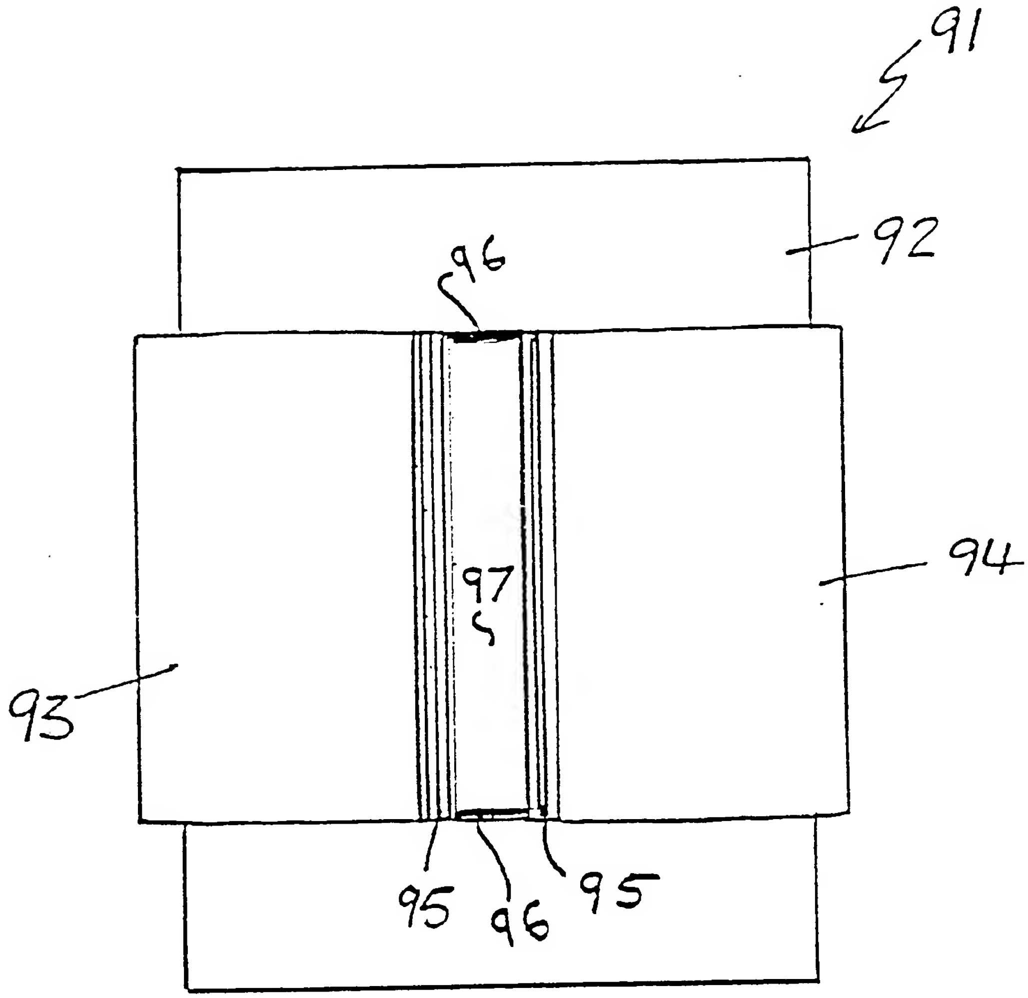

Fig 9

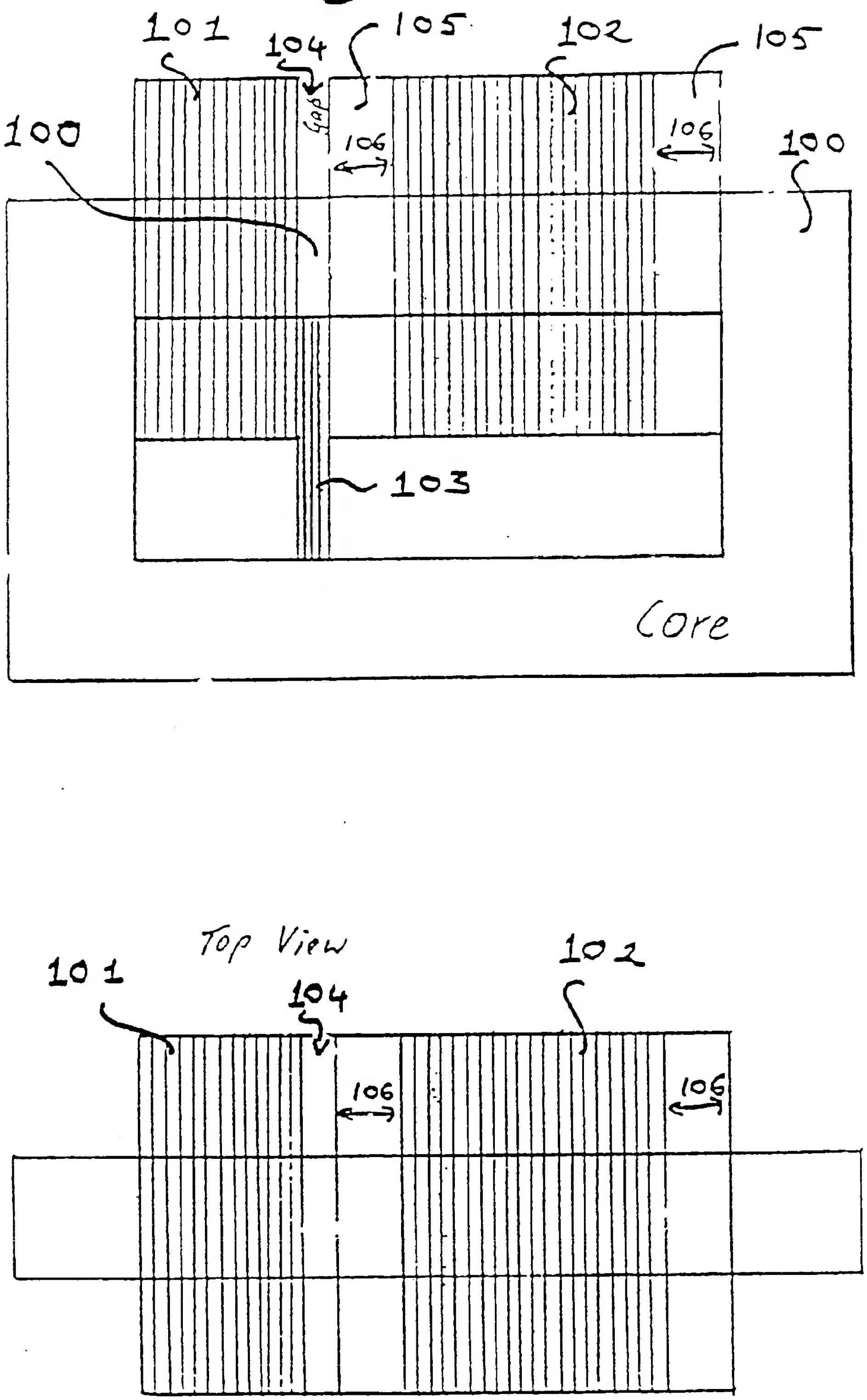
101
104
Gap
105
102
105
100
106
106
100
103
Core
Top View
101
104
102
106
106

Fig 10

INTERNATIONAL SEARCH REPORT

International Application No PCT/AU 88/00277

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[4] C01B 13/11, H01F 27/34, H01T 19/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	C01B 13/11

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US,A, 1856544 (EVANS) 3 May 1932 (03.05.32) Especially Col. 1 Lines 44-45 and the drawings	(12,13)
X	US,A, 2778795 (TRUB) 22 January 1957 (22.01.57) Especially Col. 1 Lines 35-44	(1,4)
X	US,A, 2778796 (TRUB) 22 January 1957 (22.01.57) Especially Col. 1 Lines 34-39 and the drawings	(1,4)
X	US,A, 3455803 (PUROMATIC INC.) 15 July 1969 (15.07.69) Especially Col. 4 Line 9 & Col. 5 Line 42	(12,17)
X	US,A, 3905920 (BOTCHAROFF) 16 September 1975 (16.09.75) Especially Col. 3 Lines 15-17	(12,17)
X	US,A, 4027169 (UNION CARBIDE) 31 May 1977 (31.05.77) Especially Col. 8 Lines 53-68 & Col. 6 Lines 50-51	(12,17)
X	US,A, 4156638 (0-3 COMPANY) 29 May 1979 (29.05.79) See especially Col. 6 Lines 5-19, Col. 16 Lines 16-17	(12,17)

(continued)

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
2 November 1988 (02.11.88)	10 NOVEMBER 1988 (10.11.88)
International Searching Authority	**Signature of Authorized Officer**
Australian Patent Office	J.L. Werner J.L. WERNER

Form PCT/ISA/210 (second sheet) (January 1985)

III DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
X	US,A, 4307433 (TOKYO SHIBAURA DENKI K.K.) 22 December 1981 (22.12.81) See especially the description with reference to figures 10-15 for Claim 2	(1,2)
X	US,A, 4461744 (BBC BROWN, BOVERI & CO.) 24 July 1984 (24.07.84)	(1,12)
X	US,A, 4587591 (DEGREMONT) 6 May 1986 (06.05.86) See especially Col. 2 Lines 54-60	(12,13,15)
X	US,A, 4680694 (NATIONAL DISTILLERS & CHEMICAL CORP.) 14 July 1987 (14.07.87)	(12,17)
X	AU,A, 12378/83 (GESSLAUER) 15 September 1983 (15.09.83)	(12,17)
X	GB,A, 1092974 (COMPAGNIE GENERALE DES EAUX) 29 November 1967 (29.11.67).	(1,12-16)
X	GB,A, 1515192 (MITSUBISHI DENKI K.K.) 21 June 1978 (21.06.78)	(1,12,17)
X	GB,A, 1515193 (MITSUBISHI DENKI K.K.) 21 June 1978 (21.06.78)	(1,12,17)
X	GB,A, 1549273 (UNION CARBIDE CORP.) 25 July 1979 (25.07.79)	(12,17)
X	FR,A, 599786 (BOUVIER) 20 January 1926 (20.01.26)	(1,2)
X	FR,A, 2327191 (SIGMA HRANICE NARODNI PODNIK) 6 May 1977 (06.05.77)	(1,2)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ....., because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers.........., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

Claims 1-8 and 11;
Claim 9;
Claim 10;
Claims 12-17

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

1-8,11-17

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☒ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (supplemental sheet (2)) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/AU 88/00277

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members		
US 3455803	BE 728242		
US 3905920	ES 425078	FR 2224403	
US 4027169	AU 79646/75 FI 750954 IT 1034658 SE 7503623	CA 1050099 FR 2266360 JP 50133426 US 3942093	DE 2513026 GB 1500773 NO 751082 US 4002921
US 4156638	US 4051043		
US 4307433	FR 2454995	GB 2048029	JP 55144404
US 4461744	EP 54994		
US 4587591	CA 1214208 FR 2552597	EP 136225	ES 536111
US 4680694	DE 3613411 US 4713220	FR 2580875	JP 61251487
AU 12378/83	BR 8301231 EP 88973 JP 58168319	DE 3208895 ES 520858 US 4694376	EG 15221 IN 159040
GB 1515192	CH 611248 JP 50155493	DE 2525059 US 4123664	FR 2273759
GB 1515193	CH 611249 JP 50157293	DE 2525580 US 4051045	FR 2273758
GB 1549273	AU 12010/76 FR 2303588 JP 51139575 SE 7603275 US 4283291	CA 1067854 GB 1549272 NL 7602690 US 4016060	DE 2610809 IT 1062447 NO 760892 US 4038165

END OF ANNEX